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Abdulnasser Hatemi-J and Alan Mustafa

Department of Economics and Finance, the UAE University, Department of Computer Science, the American University of Kurdistan

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Department of Economics and Finance, the UAE University and the Department of Computer Science, the American University of Kurdistan

E-mails: (AHatemi@uaeu.ac.ae) and (Alan.Mustafa@auk.edu.krd)

Abstract

This paper investigates empirically whether or not the financial market of China is integrated with the financial market of the US. Unlike most previous studies on financial market integration, we allow for asymmetry in our investigation. The underlying data is transformed into cumulative partial sums by using a software component that is created by authors in Octave language. By estimating the asymmetric generalized impulse response functions we find that the financial markets of these two biggest economies in the world are linked interactively when the markets are falling. However, no significant impact between the two underlying markets are found when markets are rising. These results support the view that allowing for asymmetry in financial markets is important and it has crucial repercussions for both policy makers and investors.

JEL Classifications: G15, G11, C32

Keywords: Financial Market Integration, Asymmetry, Impulses, US, China, Octave

1. Introduction

Whether or not financial markets are integrated has important repercussions. In case financial markets are integrated across countries it implies that the similar risk is compensated by the same level of return regardless of the origin of the market in which the underlying financial asset is traded. However, if the markets are segmented it means the trade off between the same risk and return is not the same across the markets and that in turn would imply some form of inefficiency. The issue of financial market integration or segmentation is also of paramount importance for policy makers because of the potential spill overs or the contagion effect during financial crisis. Another important issue within this context is the potential asymmetric impact that might prevail but it is usually neglected in the existing literature. It is widely agreed that financial agents react more to negative news than positive ones. Based on this argument it is necessary to allow for asymmetric effects when the issue of financial market integration in investigated empirically in order to figure out whether or not there is more integration when markets are falling compared to when markets are rising. We investigate the financial market integration between the world's two largest economies during the period 2009-2015 on monthly basis. We make use of newly developed asymmetric generalized impulse response functions by Hatemi-J (2014). This approach separates explicitly the impact of positive changes from the negative ones.

The rest of the article is organized as the following. In Section 2 we provide a brief literature review on financial market integration. The underlying econometric methodology is described in Section 3. Section 4 presents the empirical findings. The last section offers the concluding remarks.

2. A Brief Literature Review

Integration of financial markets across border can cause efficient distribution of scarce resources which in turn results in increasing economic growth according to Calvi (2010). Whether or not financial markets are integrated is still an open question since there is no agreement on this issue in the exiting literature. Different published articles report different results. Among studies that support financial market integration Agmon (1972), Wheatley (1988), Hamao et al. (1990), Espitia and Santamaria (1994), Hammoudeh and Choi (2006) can be mentioned. On the other hand, there are studies that conclude financial markets are not integrated such as studies conducted by Grubel,

(1968) Makridakis and Wheewright (1974) Adler and Dumas (1983) Smith et. al., (1995) and Hatemi-J and Roca (2004).[1]

An important issue within this context that deserves more attention than given in the existing literature is the asymmetric issue. In fact, authors like Alvarez-Ramirez et. al. (2009) and Hong and Zhou (2008) have explicitly shown that cross-correlation between financial markets is characterized by an asymmetric structure. However, except for few cases, it seems to be common practice to investigate empirically the issue of financial market integration without allowing for the separation of positive changes from the negative ones. As an exception, Hatemi-J (2012a) tests for asymmetric causal impact of the US market on the UAE market.[2] The mentioned author concludes that the UAE market is integrated with US market and this integration appears to be stronger when markets are falling. In this paper, we measure the degree of integration of the Chinese market with the US market by estimating asymmetric the generalized impulse response functions. This new methodology that is capable of separating the impact of positive chocks from the negative ones is described in the next section.

3. The Econometric Methodology

As mentioned, we make use of asymmetric generalized impulse response functions in order to figure out empirically whether the financial markets of the US and China are integrated or segmented. This methodology is developed recently by Hatemi-J (2014), which separates the impact of positive chocks from the negative ones explicitly. Since the stock price index in each market is integrated of the first order with both drift and trend each variable can be expressed as the following:

$$P_{1t} = a + bt + P_{1t-1} + \varepsilon_{1t}, \tag{1}$$

and

[1] For some newer studies on international financial integration the interested reader is referred to Frey and Hussinger (2011), Kenourgios and Samitas (2011), Claus and Lucey (2011), Büttner and Hayo (2012) and Olivero and Madak (2013) among others.
[2] An asymmetric causality test developed by Hatemi-J (2012b) was used for this purpose.

$$P_{2t} = \alpha + \beta t + P_{2t-1} + \varepsilon_{2t}, \tag{2}$$

where $t = 1,2,\ldots T$, P_1 and P_2 are the stock price indexes, and the variables ε_1 and ε_2 are the white noise disturbance terms. The denotations a, b, α, β represent constants. By applying the recursive method, the solutions to equations (1) and (2) are given as the following:[3]

$$P_{1t} = at + \frac{t(t+1)}{2} b + P_{1,0} + \sum_{i=1}^{t} \varepsilon_{1i}, \tag{3}$$

$$P_{2t} = \alpha t + \frac{t(t+1)}{2} \beta + P_{2,0} + \sum_{i=1}^{t} \varepsilon_{2i}, \tag{4}$$

Positive and negative changes for the first index can be defined as the following:

$$P_{1t}^{+} = \frac{at + \left[\frac{t(t+1)}{2}\right] b + P_{1,0}}{2} + \sum_{i=1}^{t} \varepsilon_{1i}^{+}, \tag{5}$$

and

$$P_{1,t}^{-} = \frac{at + \left[\frac{t(t+1)}{2}\right] b + P_{1,0}}{2} + \sum_{i=1}^{t} \varepsilon_{1i}^{-}. \tag{6}$$

Similarly, positive and negative changes for the second index can be defined as the following:

[3] For a representation of the underlying equations in matrix format along with mathematical proofs of the solutions see Hatemi-J and El-Khatib (2016).

$$P_{2t}^{+} = \frac{\alpha t + \left[\frac{t(t+1)}{2}\right]\beta + P_{2,0}}{2} + \sum_{i=1}^{t} \varepsilon_{2i}^{+}, \qquad (7)).$$

and

$$P_{1,t}^{-} = \frac{at + \left[\frac{t(t+1)}{2}\right]b + P_{1,0}}{2} + \sum_{i=1}^{t} \varepsilon_{1i}^{-}. \qquad (8)$$

It should be mentioned that the positive and negative shocks can be identified as follows: $\varepsilon_{1i}^{+} = \max(\varepsilon_{1i}, 0)$, $\varepsilon_{2i}^{+} = \max(\varepsilon_{2i}, 0)$, $\varepsilon_{1i}^{-} = \min(\varepsilon_{1i}, 0)$ and $\varepsilon_{2i}^{-} = \min(\varepsilon_{2i}, 0)$. The cumulative partial sums presented by equations (5)-(8) can be utilized for estimating the asymmetric generalized impulse response functions according to Hatemi-J (2014). The transformation of the underlying data is implemented by using a statistical software component created by Hatemi-J and Mustafa (2016). Octave (Eaton et. al., 2015) software language is used by the mentioned authors to develop a module for transforming the underlying data. Octave is a software environment for developing applications to convert a mathematical algorithm into machine language which can run on computers with faster execution of mathematical computations. Octave is very similar to MATLAB and it holds free license. The software code is available online.

These cumulative sums can be used to estimate the asymmetric generalized impulse response functions. In the following, our presentation focuses only on the case of estimating the impulses for positive cumulative shocks.[4] Namely, assuming that our information vector is $X_t^{+} = (P_{1t}^{+}, P_{2t}^{+})$ the following vector autoregressive model of order *k*, i.e. VAR (*k*), can be estimated in order to generate the impulse response functions:

$$X_t^{+} = B_0 + B_1 X_{t-1}^{+} + \ldots + B_k X_{t-k}^{+} + u_t^{+} \qquad (9)$$

[4] To estimate impulses for negative cumulative shocks the vector $X_t^{-} = (P_{1t}^{-}, P_{2t}^{-})$ is used.

Here B_0 is a $2{\times}1$ vector, B_s (s=1, …, k.) is a $2{\times}2$ matrix, and u_t^+ is a $2{\times}1$ vector of error terms. The optimal lag order, k, is determined by minimizing an information criterion proposed by Hatemi-J (2003, 2008). This information criterion is presented as the following:

$$HJC = \ln\left(\left|\widehat{\Omega}_k^+\right|\right) + k2^{-1}T^{-1}\left(m^2\ln T + 2m^2\ln(\ln T)\right), \qquad k = 0, \cdots, k_{max}. \tag{10}$$

where $\left|\widehat{\Omega}_k^+\right|$ is the determinant of the estimated variance-covariance matrix of the error term in the VAR model using lag order k, m signifies the number of variables and T is representing the sample size. After determining the optima lag order via minimizing the information criterion, the requested impulses response functions can be generated as follows. In order to estimate the impulses of interest we need to represent the VAR model, i.e. equation (9), in the moving average format as follows:

$$X_t^+ = \sum_{i=0}^{\infty} C_i + \sum_{i=0}^{\infty} A_i u_{t-i}^+, \qquad \text{for t} = 1, \cdots, \text{T}. \tag{11}$$

where the $2{\times}2$ coefficient matrixes (A_i) are estimated recursively as the following:

$$A_i = B_1 A_{i-1} + B_2 A_{i-2} + \cdots + B_k A_{i-k}, \quad \text{for } i = 1,\ 2, \cdots, \tag{12}$$

with $A_0 = I_2$ and $A_i = 0, \forall i < 0$, and $C_i = A_i B_0$. The asymmetric generalized impulse response of the effect of a standard error shock in the jth equation at time t on the vector X_{t+n}^+ is estimated as:

$$AGIR(n) = \sigma_{jj}^{-0.5} A_n \Omega e_j, \text{ for } n = 0,1,2, \cdots, \tag{13}$$

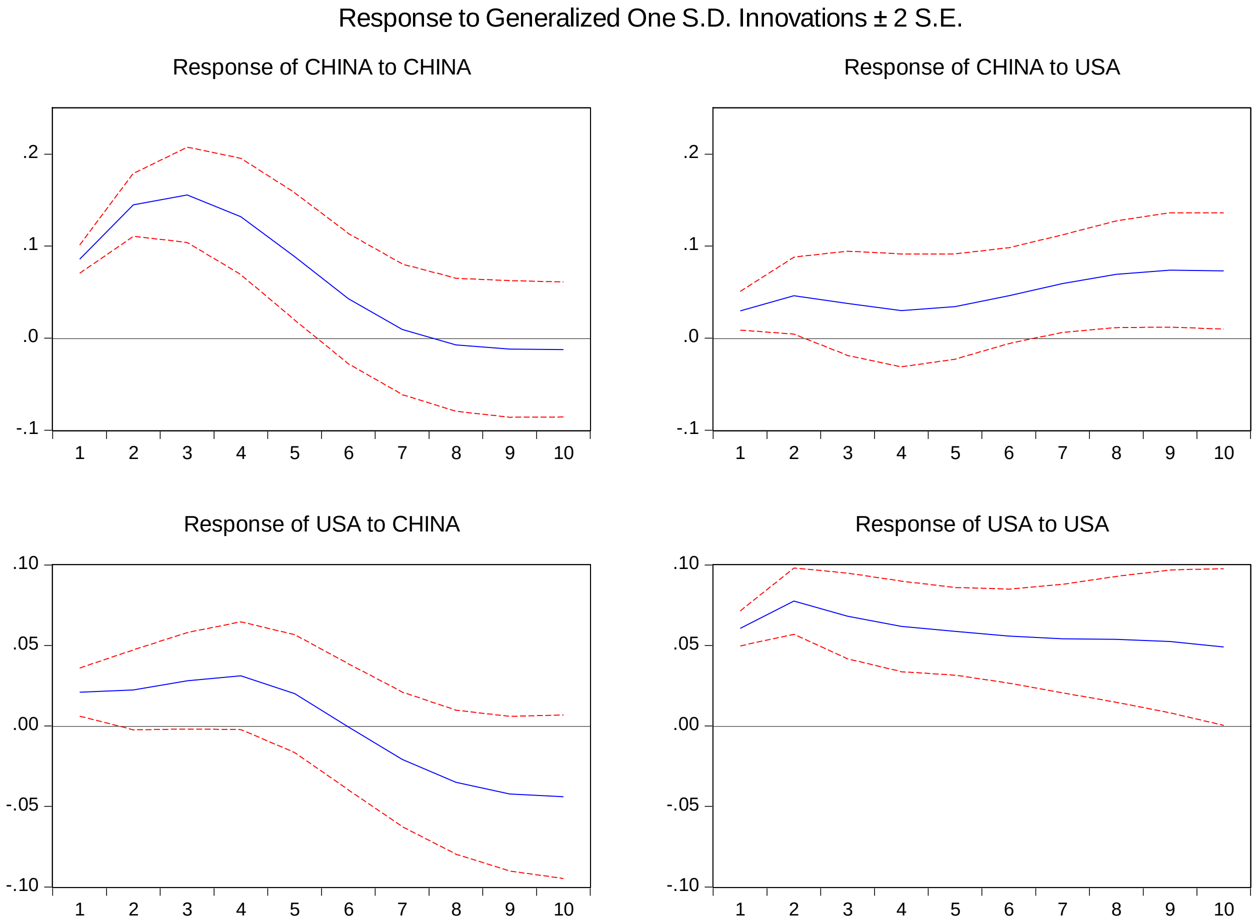
The denotation Ω is representing the variance-covariance matrix in the VAR model. That is $\Omega = \{\sigma_{ij}, i, j = 1, 2.\}$. The denotation e_j is a 2×1 indicator vector in such a way that its *j*th element is one and all other elements are zero.[5] The estimated impulses are presented with a 95% confidence interval in order to test the statistical significance of each estimation.

4. The Estimation Results

The source of our data is the FRED data base, which is provided by the Federal Reserve Bank of St. Louise, which is available online. The data set is on monthly basis and it cover the January of 1999 until the January of 2016. The estimation results are presented in Figures 1-3. The results of standard generalized impulse response functions that do not take into account potential asymmetric effects are presented in Figure 1.

[5] It should be pointed that the asymmetric forecast error variance decomposition, denoted by $AVD_{ij}(n)$, could be estimated as $AVD_{ij}(n) = \dfrac{\sigma_{ii}^{-1}\sum_{l=0}^{n}\left(e_i' A_l \Omega e_j\right)^2}{\sum_{l=0}^{n} e_i' A_l \Omega A_l' e_i}$, *ij*= 1, 2.

Figure 1. Results for Symmetric Generalized Impulse Response Functions.



As it is evident from Figure 1, there is no strong support for financial market integration between US and China since the majority of responses to the other market is not statistically significant.

Figure 2. Results for Asymmetric Generalized Impulse Response Functions for Positive Chocks.

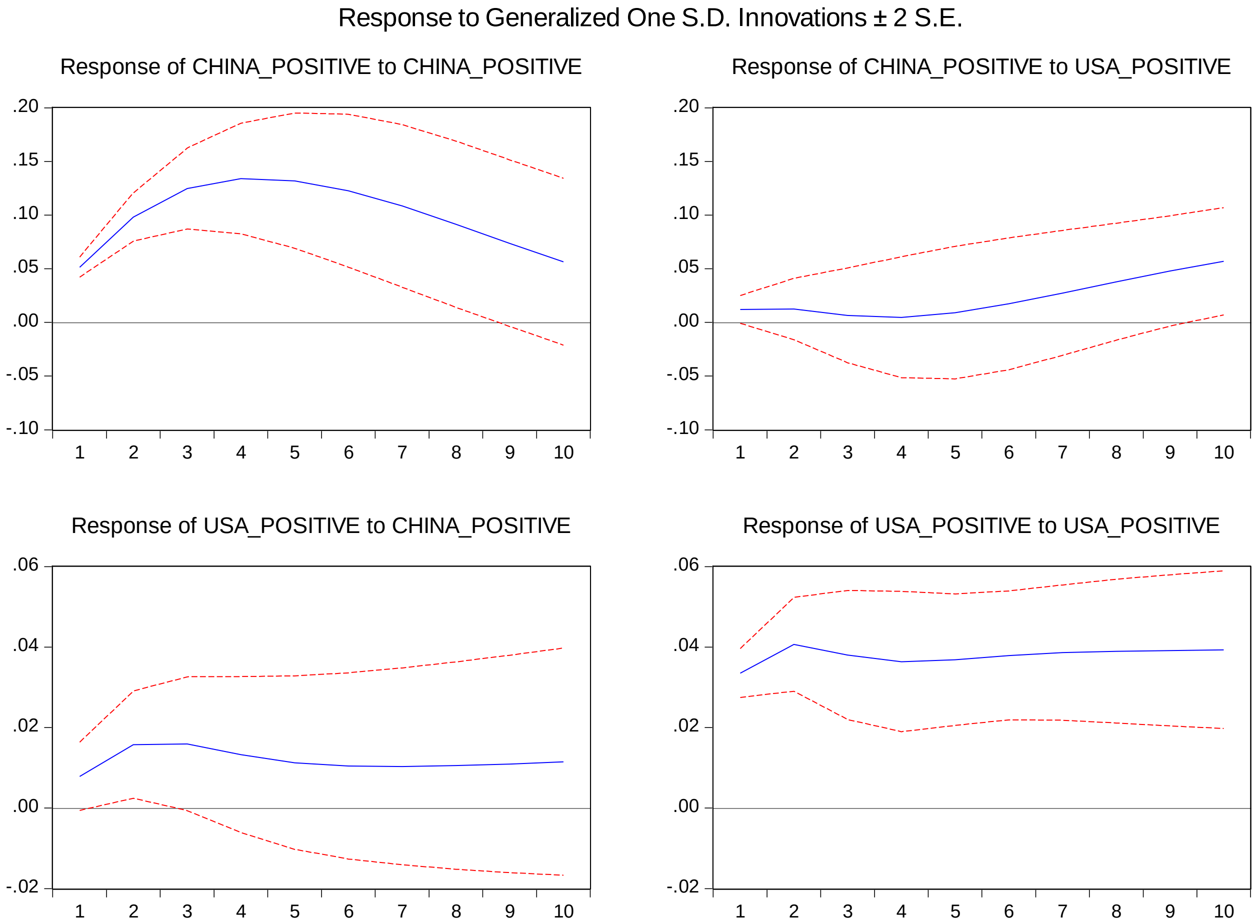
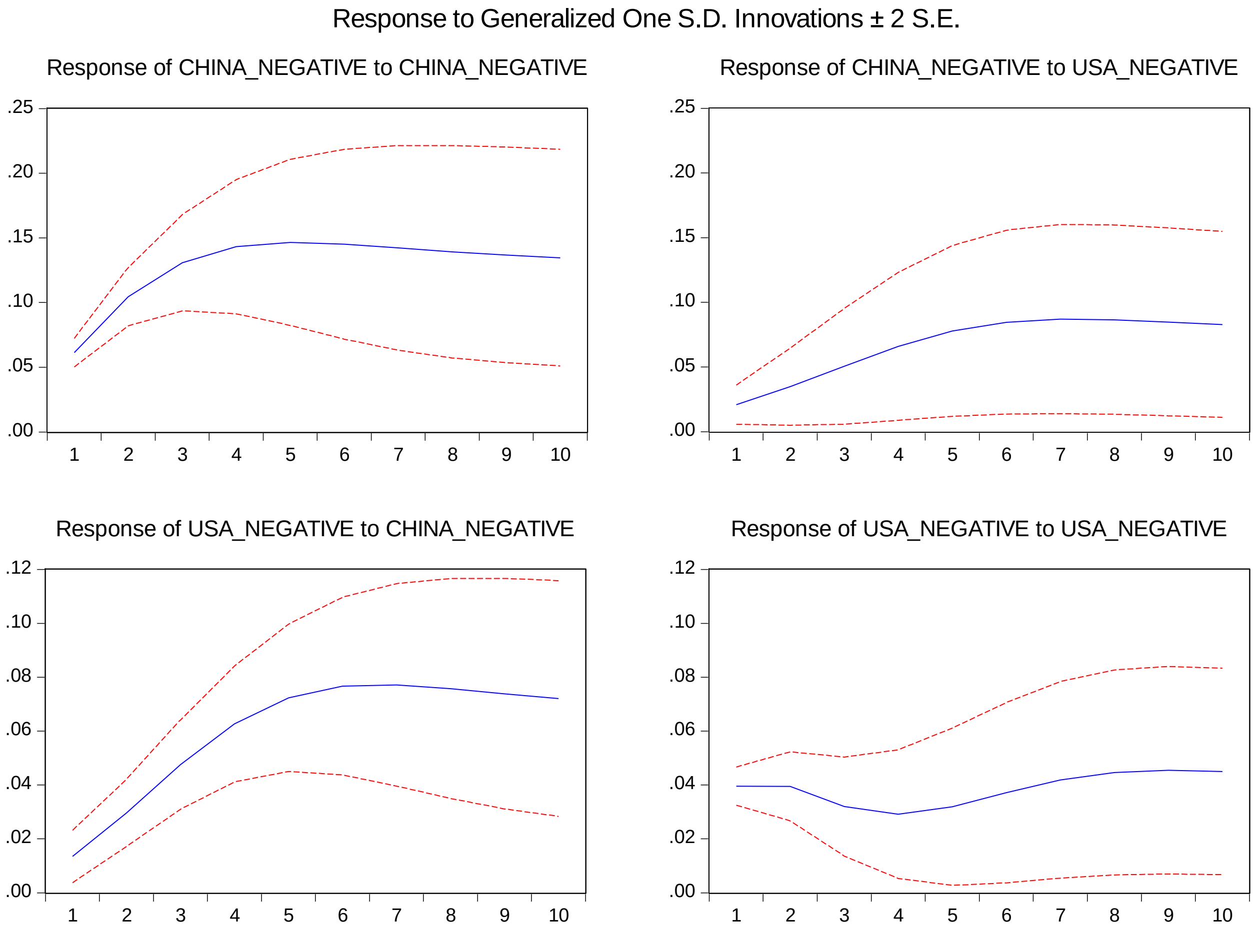


Figure 2, presents the estimation results for positive shocks. Relaying on these results we can see that the markets are not integrated when the prices are falling. This conclusion is based on the fact that a positive shock in any market does not produce a significant response in the other market.

Figure 3. Results for Asymmetric Generalized Impulse Response Functions for Negative Chocks.



The results for negative chocks are presented in Figure 3, which reveal that both market are integrated with each other. As can be seen from this figure a negative shock in the US market results in a significant negative shock in the Chinese market. The reviser response is also significant.

4. Conclusions

This paper measures the degree of financial market integration between the world's two largest economies. Unlike previous studies, we allow for asymmetry when the generalized impulse response functions are estimated. The underlying data is transformed into cumulative partial sums for positive and negative changes by using a software component created in Octave by the authors which is available online. Our estimation results of the impose response functions show that the two underlying markets are not integrated when no asymmetry is allowed in the estimations. However, the asymmetric estimations reveal that the markets are indeed integrated when prices are falling. Such evidence is not found when the prices are rising. These results imply that if any market is falling it might pull down the other market as well. Hence, necessary cautious policies might be necessary in order to neutralize any negative impact from one market to the other in case it happens.

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